Good Study

AN INDIVIDUAL HONORS STUDY PROJECT

The Relationship of Soil Moisture to Crack Magnitude During a Wet-Dry Cycle and Effects Upon Infiltration and Sedimentation in the Maumee River Basin for Two Heavy Clay Soils

By

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I want to thank Mr. and Mrs. Buttermore, Mr. and Mrs. Cusac, The Allen County SCS Staff, Dr. Terry Logan, Mike Thompson and all the people in the Agronomy Department who helped me with this paper.

I dedicate this paper to Robin, T.J., and Shane, who never complained or called me crazy for looking at the cracks in the ground all summer and without whose help this paper would never have come about.

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INTRODUCTION

Erosion from lands in the Maumee River Basin and the accompaning sedimentation in the Maumee River and Lake Erie have been problems which the local residents have faced for years. The problem of erosion-sedimentation is further compounded by the increased use of fertilizers and pesticides which are carried along with the sediments and into the Maumee River and Lake Erie. The effects of the problem, however, are not limited to only that region. The Maumee Basin-Lake Erie region is a major commercial center for industrial and agricultural goods which affects the economy and well-being of both the U.S. and Canada. The importance of this region and it's problems ~~has~~ have been recognized by local, state and Federal goverments and was therefore chosen for the first "Level B" study by the Great Lakes Basin Commission under the Water Resources Planning Act (P.L. 89-80) and the Federal Water Pollution Control Act Amendments of 1972 (Section 209, P.L. 92-500). *1*

The predominant soils of this region are deep, dark colored and very poorly drained soils which occur in the Lake Plain Region of northwestern Ohio, northeastern Indiana, and southeastern Michigan. These include Hoytville, Pewano, Paulding, Latty and Toledo soils. There are approximately over 900,000 acres of Hoytville soils in the Maumee Basin. *2*

Heavy Clays

One characteristic ~~in~~ which these soils have in common, are their high shrink-swell capacities in relation to soil moisture. These high shrink-swell capacities are responsible for a high degree of cracking (cracks in the soil) which occurs when the soil shrinks (drys out). *2*

Little research has been done to measure the magnitude of these cracks, their relation to soil moisture content, infiltration of rainfall, through the cracks, and sediment-nutrient loss through the cracks to tile.

Some research has been done, however, on sediment nutrient losses through tile, but not in relationship to the cracks in the soil. These include: Semi-Annual Report, Maumee River Basin Watershed Study, October 1976, Terry J. Logan, project leader; *3* Quality of Drainage Water from a Heavy-Textured Soil, G.O. Schwab, et. al., 1973 *5* Sediment From Drainage Systems for a Heavy Soil, G.O. Schwab, et. al., 1975 *4*; and Chemical and Sediment Movement From Agricultural Land Into Lake Erie, G.O. Schwab and E.O. Mclean, 1972 *6*.

OBJECTIVES

The objectives of this project are:

1. Determine during a Wet to Dry cycle of soil moisture the changes of Crack Magniture in:
   A. Total Length
   B. Depth
   C. Width
   D. Surface Area
   E. Volume
   F. General Surficial Shape
2. Determine the relationship of crack magnitude to soil moisture content.
3. Determine how the changes in crack magnitude might effect:
   A. Infiltration
   B. Sediment Loss
   C. Nutrient-Pesticide Movement

METHODS AND PROCEDURES

Two, 4 foot by 4 foot (16 square feet) plots were chosen near McComb, Ohio (northwest of Findlay). One was Pewamo Clay and the other Hoytville clay. (See soils and location maps ~~716~~ 7,16, one and two) These sites were chosen for the following reasons:

1. The sites represented two different types of the heavy crack clays.
2. The sites were located near each other (within two miles), so that weather conditions (rainfall) would not be greatly different.
3. The sites were fairly close to the author's home (within a 45 minute drive).
4. The sites were not far away from access roads (within 350 feet).
5. The sites were in wheat and oats so that interference by tillage would not be a problem.

The Hoytville clay site existed in the Lake Plain Region of Hancock County, while the Pewamo Clay existed within the northern edge of the Defiance End Moraine. (See Figure 3) *7*.

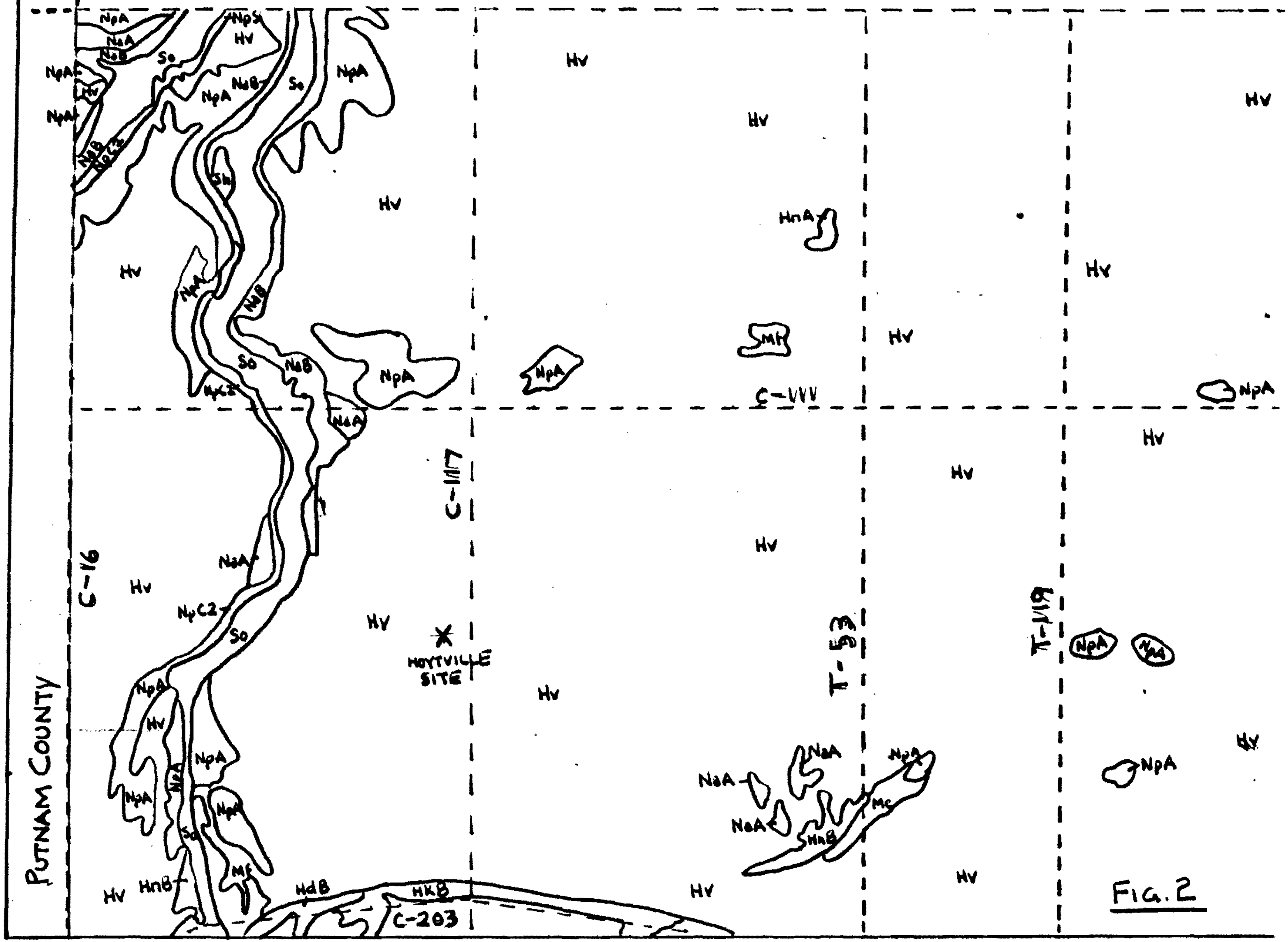
Data was gathered whenever the cracks seemed to be in a period of change in magniture or moisture conditions changed.

Each plot was marked off by four wooden stakes connected by string. All vegetation was removed by cutting with hand shears so that the cracks could be measured and photographed.

Each time the sites were visited the following data was gathered and recorded:

1. Total length of cracks - this was measured by a string.
2. Width of cracks - this was measured by a tape measure.
   The variance of greatest width to narrowest was noted, and an approximate average computed.

FIG. 1



Hv
NpA
NaA
NaB
So
NpS
NpC2
Sh
MH
HnA
Mc
HnB
HdB
HKB
Mf
C-VVV
C-117
C-16
C-203
T-119
HOYTVILLE SITE
PUTNAM COUNTY

FIG. 2

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, or D, shows the slope. Most symbols without a slope letter are those of nearly level soils, but some are for land types that have a considerable range in slope. A final number, 2, in the symbol shows that the soil is moderately eroded.

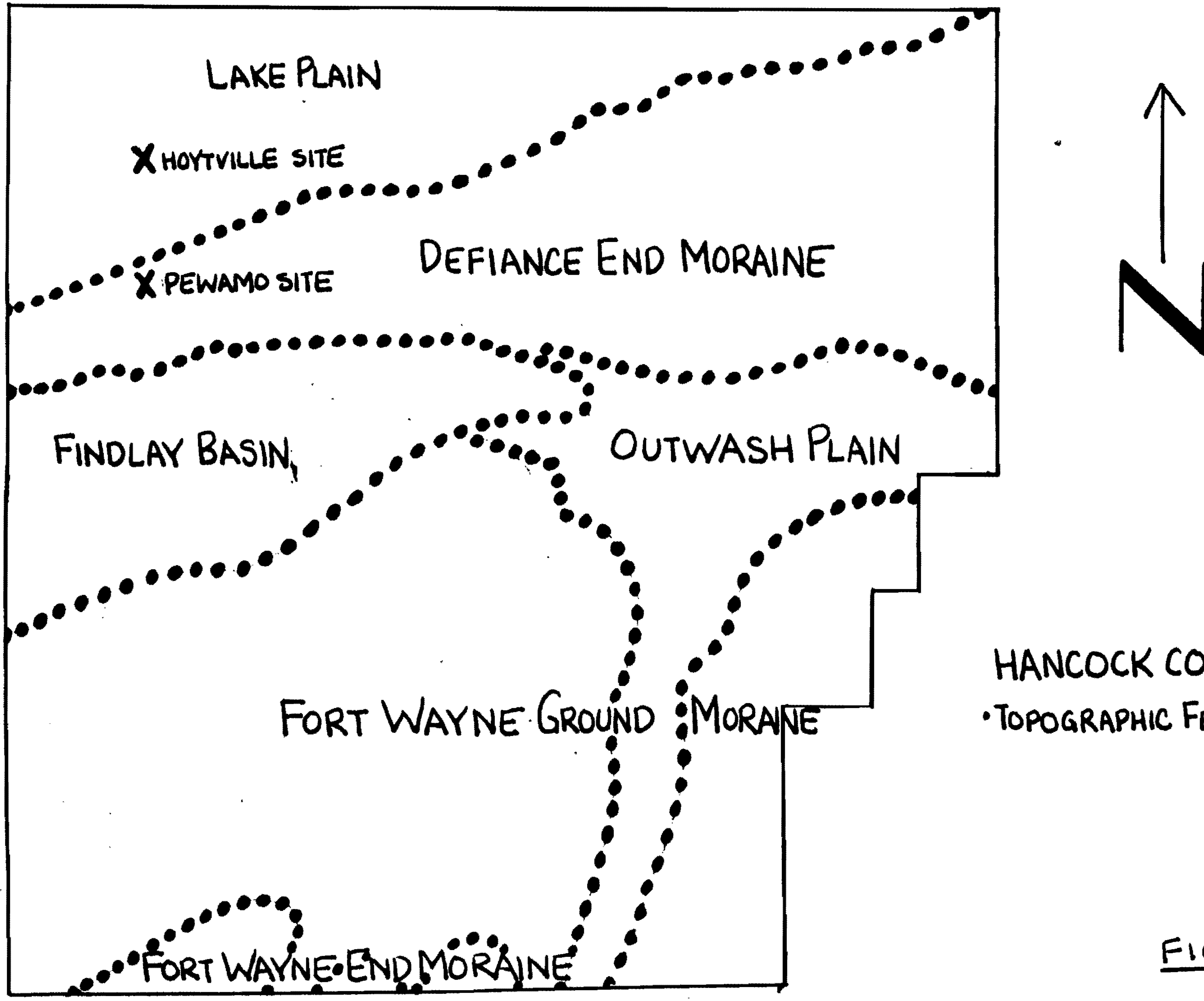
SYMBOL	NAME
Ad	Adrian muck
BlA	Belmore sandy loam, 0 to 2 percent slopes
BlB	Belmore sandy loam, 2 to 6 percent slopes
BmA	Belmore loam, 0 to 2 percent slopes
BmB	Belmore loam, 2 to 6 percent slopes
BmC	Belmore loam, 6 to 12 percent slopes
BnA	Blount loam, 0 to 2 percent slopes
BnB	Blount loam, 2 to 6 percent slopes
BoA	Blount silt loam, 0 to 2 percent slopes
BoB	Blount silt loam, 2 to 6 percent slopes
BoB_2	Blount silt loam, 2 to 6 percent slopes, moderately eroded
CeA	Celina silt loam, limestone substratum, 0 to 2 percent slopes
Cl	Clay pits
Co	Colwood loam
CrA	Crosby silt loam, limestone substratum, 0 to 2 percent slopes
Cu	Cut and fill land
DgA	Digby sandy loam, 0 to 2 percent slopes
DmA	Digby loam, 0 to 2 percent slopes
DmB	Digby loam, 2 to 6 percent slopes
DuB	Dunbridge loamy fine sand, 2 to 6 percent slopes
Ea	Eel loam
Em	Eel silt loam
FtA	Fulton silt loam, 0 to 2 percent slopes
FtB	Fulton silt loam, 2 to 6 percent slopes
Gn	Genesee silt loam
Go	Granby loamy fine sand
Gp	Gravel pits
HaA	Haney sandy loam, 0 to 2 percent slopes
HaB	Haney sandy loam, 2 to 6 percent slopes
HdA	Haney loam, 0 to 2 percent slopes
HdB	Haney loam, 2 to 6 percent slopes
HkA	Haskins fine sandy loam, 0 to 2 percent slopes
HkB	Haskins fine sandy loam, 2 to 6 percent slopes
HnA	Haskins loam, 0 to 2 percent slopes
HnB	Haskins, 2 to 6 percent slopes
Hv	Hoytville clay

SYMBOL	NAME
Jo	Joliet silty clay loam
KfA	Kibbie fine sandy loam, 0 to 2 percent slopes
KfB	Kibbie fine sandy loam, 2 to 6 percent slopes
KlA	Kibbie loam, 0 to 2 percent slopes
KsA	Kibbie silt loam, 0 to 2 percent slopes
KsB	Kibbie silt loam, 2 to 6 percent slopes
Le	Lenawee loam
Ln	Lenawee silty clay loam
Lw	Linwood muck
Me	Mermill loam
Mf	Mermill clay loam
Mg	Millgrove fine sandy loam
Mh	Millgrove loam
Mk	Millgrove clay loam
Mm	Millsdale loam
Mn	Millsdale silt loam
Mo	Millsdale silty clay loam
MrA	Milton silt loam, 0 to 2 percent slopes
MrB	Milton silt loam, 2 to 6 percent slopes
MsB	Marley loam, 2 to 6 percent slopes
MyB	Morley silt loam, 2 to 6 percent slopes
MyB_2	Morley silt loam, 2 to 6 percent slopes, moderately eroded
MyC	Morley silt loam, 6 to 12 percent slopes
MyC_2	Morley silt loam, 6 to 12 percent slopes, moderately eroded
MyD_2	Morley silt loam, 12 to 18 percent slopes, moderately eroded
NaA	Nappanee loam, 0 to 2 percent slopes
NaB	Nappanee loam, 2 to 6 percent slopes
NpA	Nappanee silt loam, 0 to 2 percent slopes
NpB	Nappanee silt loam, 2 to 6 percent slopes
NpC_2	Nappanee silt loam, 4 to 10 percent slopes, moderately eroded
OtB	Ottokee loamy fine sand, 0 to 4 percent slopes
Pm	Pewamo silty clay loam
Po	Pewamo clay
Qu	Quarry
RbA	Randolph loam, 0 to 2 percent slopes
RlA	Randolph silt loam, 0 to 2 percent slopes
RlB	Randolph silt loam, 2 to 6 percent slopes
RmA	Rawson loam, 0 to 2 percent slopes
RmB	Rawson loam, 2 to 6 percent slopes
RnA	Rimer loamy fine sand, 0 to 2 percent slopes
RnB	Rimer loamy fine sand, 2 to 6 percent slopes

SYMBOL	NAME
RrB	Ritchey silt loam, 1 to 5 percent slopes
RsC	Romeo silt loam, 0 to 10 percent slopes
SdA	Seward loamy fine sand, 0 to 2 percent slopes
SdB	Seward loamy fine sand, 2 to 6 percent slopes
SeB	Shinrock silt loam, 2 to 6 percent slopes
Sh	Shoals silt loam
Sn	Sloan Loam
So	Sloan silty clay loam
To	Toledo silty clay loam
TpA	Tuscola fine sandy loam, 0 to 2 percent slopes
TpB	Tuscola fine sandy loam, 2 to 6 percent slopes
TsB	Tuscola loam, 2 to 6 percent slopes
VaB	Vaughnsville loam, 1 to 4 percent slopes

Road....---------

Drainway...-.-.-.-



HANCOCK COUNTY
·TOPOGRAPHIC FEATURES·

FIG. 3

3. Depth of cracks - this was measured by a steel tape measure with the end bent outwards to make it less than one fifth of an inch in width.
4. Surface shape of cracks - two pictures were taken with an instamatic camera. A sheet of paper was placed in the picture that identified the date and site. Also, a tape measure and ball point pen were placed in the picture to show the approximate size of the cracks.
5. Soil moisture content - samples of the soil were taken with a soil probe at 6 inch intervals to the average crack depth. These 6 inch samples (approximately one inch in diameter were then placed in plastic bags, sealed; marked as to date, site and interval; and kept refrigerated at home until analysis.
6. Rainfall - the landowners were very helpful and kept records of percipitation.

At home, the plastic bags which contained the soil moisture samples were weighed on a triple-beam balance to the nearest tenth of a gram. The soil was then placed in aluminum pie pans and baked in an oven at 250F for two hours to drive off all moisture. The soil was then reweighed again and the difference between the weights and percent moisture content of the soil calculated.

All data was recorded and placed graphically on charts to show the changes in the different parameters of crack magnitude with time.

The percent of total surface area that the cracks occupied was calculated from length and width measurements. Also, the approximate volume of the cracks was estimated by projecting that the subsurface shape of the cracks conformed roughly to the shape of an isosceles triangle. The average width of the crack (for each day data was gathered) was drawn on a long sheet of paper and the average depth measured (which at that depth the crack was a little less then one fifth of an inch (o.5cm) in width. The sides of the triangle were then extended to give a true isosceles triangle and it's surface area calculated. The surface area was then multiplied times the total length of the cracks to give the approximate volume of the cracks. Percent of surface area and volume were then also graphed to show their changes with time.

RESULTS

Pewamo Clay

What

Profile Description *8*

Ap-0-8 inches, black (10 YR 2/1) clay; medium, fine, subangular blocky structure; firm, neutral; abrupt, smooth boundary.

B21tg-8-13 inches, very dark grey (10 YR 3/1) clay; common, medium, distinct, yellowish-brown (10 YR 5/8) mottles; moderate, medium subangular blocky structure; firm, thin continuous dark-grey (10 YR 4/1) clay films; neutral; clear wavy boundary.

B22tg-13-20 inches, grey (10 YR 5/1) clay; common medium, distinct, yellowish brown (10 YR 5/6) mottles; moderate medium subangular blocky structure; firm; thin continuous, dark-grey (10 YR 4/1) clay films; neutral; clear wavy boundary.

B23tg-20 to 38 inches, grey (N 5/0) clay; common, medium distinct, yellowish-brown (10 YR 5/6) mottles; moderate, coarse, subangular blocky sturcture; firm; thin; continuous, dark-grey

(10 YR 4/1) clay films; igneous pebbles, some shale fragments; neutral; diffuse, wavy boundary.

B3t-38-44 inches, grey (10 YR 5/1) clay; common, medium, distinct yellowish-brown (10 YR 5/6) mottles, moderate, coarse, subangular blocky structure; firm; thin patchy dark-grey (10 YR 4/1) clay films on vertical faces; neutral; gradual wavy boundary.

C - 44+ inches grey (10 YR 5/1) clay loam; common, coarse, distinct, yellowish brown (10 YR 5/6) and grey (10 YR 5/1) mottles, massive, firm; calcareous.

Rainfall

1.2 and 1.3 inches of rainfall were received on July 6th and 7th. Wheat was combined off the field on July 12th. Hot dry weather was experienced July 11th through July 17th. July 20th was very humid and 0.5 inches was received in two hours on July 21st. July 22nd 1.1 inches of rain fell in one half hour, followed by 0.8 inches on July 23rd. Additional did not come until August 12th when 2.7 inches of rain fell. (See Figure 4)

Soil Moisture in Percent

Soil moisture was taken in two increments 0-6" and 6-12". The 0-6" segment flucuated to a greater extent then the 6-12" segment probably reflecting quicker drying by evaporation because it was closest to the surface.

For the most part the 6-12" segment had a higher moisture content than the 0-6" segment. (See Figure 5)

Total Crack Length

Length fluctuated from a low of 132 cm (on July 24th) to a

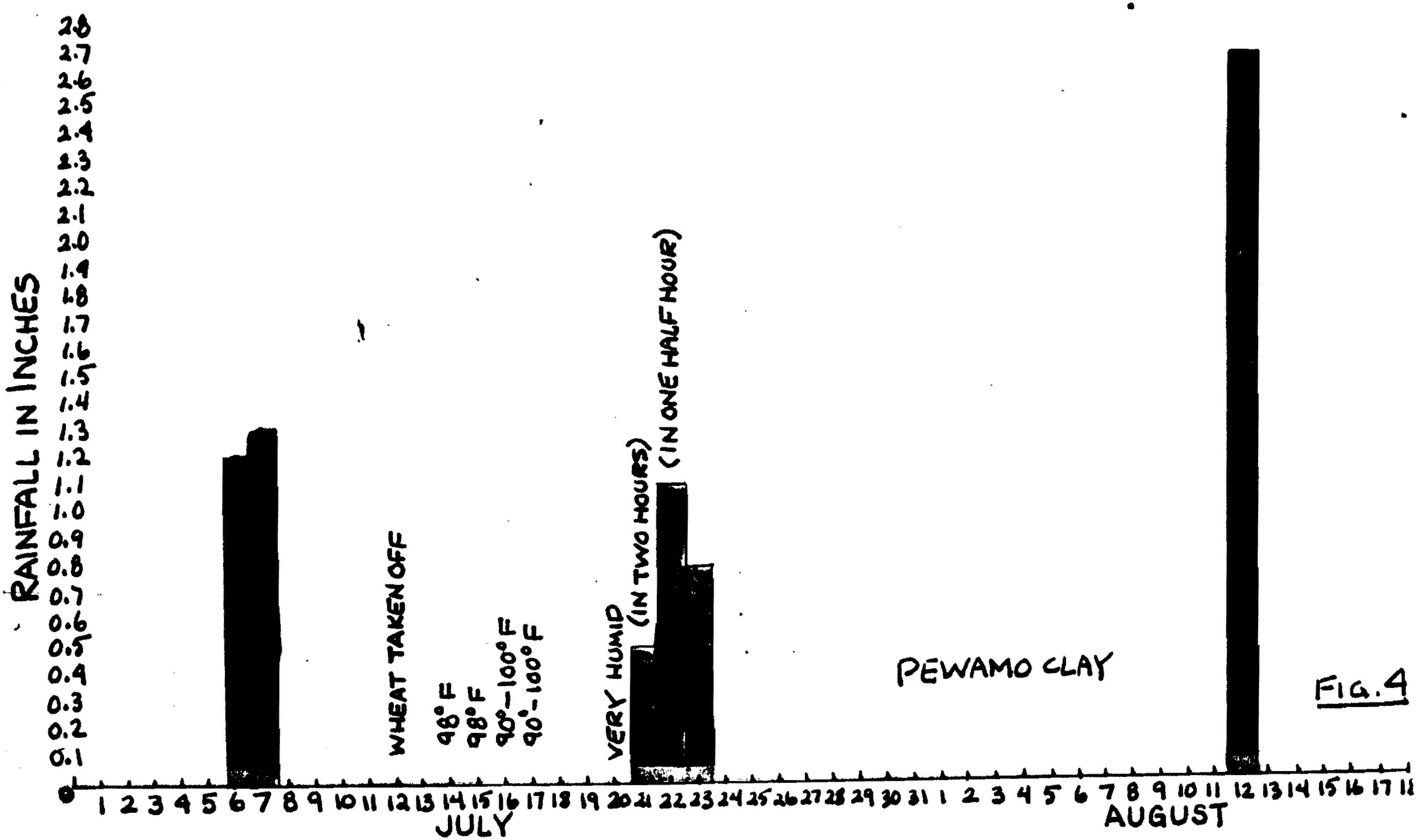

RAINFALL IN INCHES
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
WHEAT TAKEN OFF
98° F
98° F
90°-100° F
90°-100° F
VERY HUMID
(IN TWO HOURS)
(IN ONE HALF HOUR)
PEWAMO CLAY
JULY
AUGUST

FIG. 4

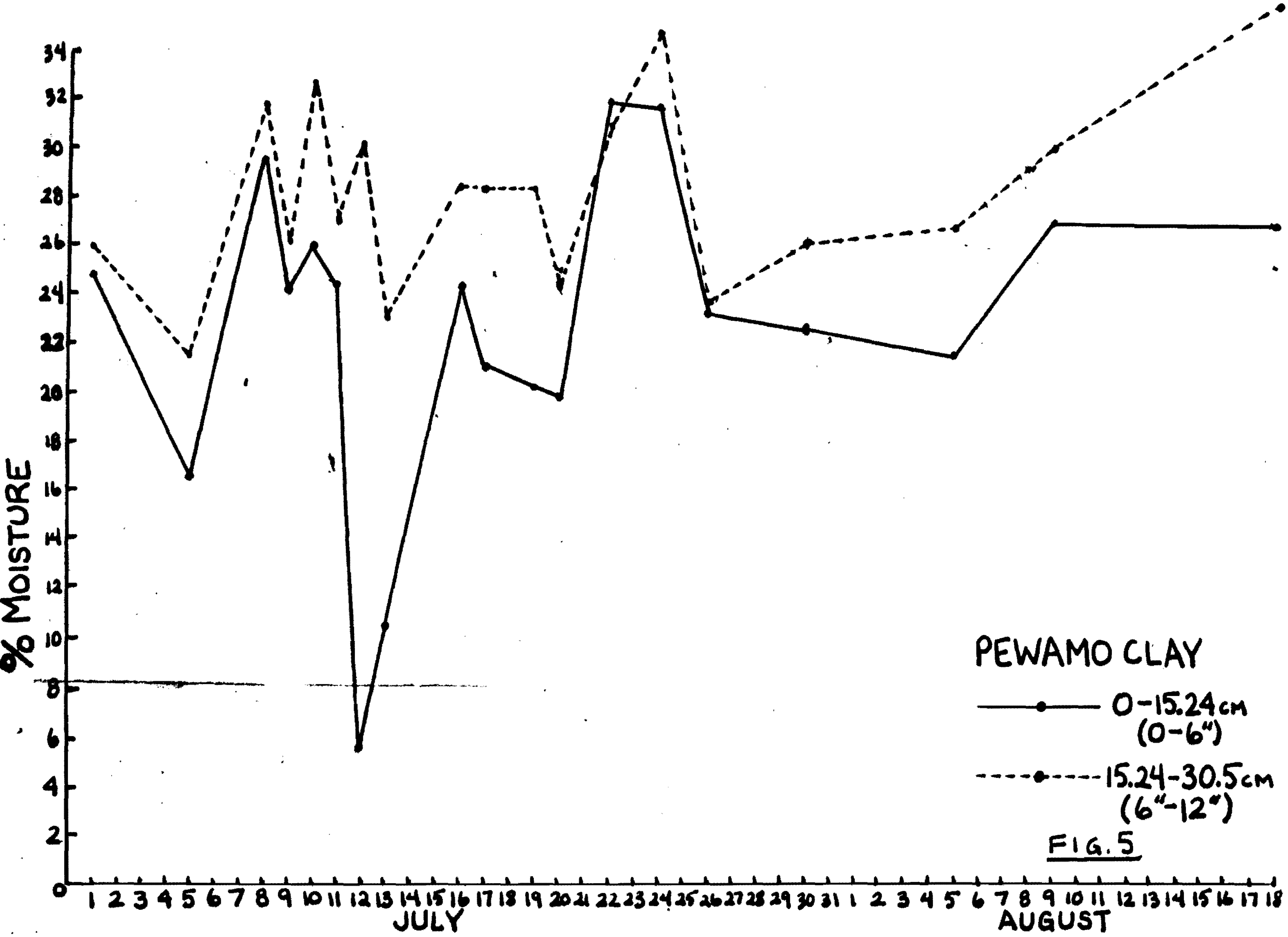

% MOISTURE
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JULY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
AUGUST
PEWAMO CLAY
0-15.24 CM
(0-6")
15.24-30.5 CM
(6"-12")

FIG. 5

high of 1016 cm on August 5th. (See Figure 6)

Crack Depth

Average crack depth fluctuated from a high of 30 cm on July 5th to a low of 5 cm on August 18th. Variance in depth at any given instance was high usually 30 cm. (See Figure 7)

Crack Width

Average crack width fluctuated from a high of 2.5 cm on July 17th-20th to a low of 0.3 on August 5th-18th. Much variance in crack width at any given time was observed (usually 5.0 cm variance.) (See Figure 8)

Crack - Percent of Total Surface Area

The percent of total surface area which was occupied by the cracks varied greatly from up to 10% on July 20th to as a low of 0.6% on July 24th. (See Figure 9)

Volume of Cracks

The volume of the cracks within the soil also varied greatly from 24,8500 cm^3 on July 5th to 658 on August 9th. (See Figure 10).

HOYTVILLE CLAY

Oats & Alfalfa

Profile Description *8*

Ap0-8 inches, very dark greyish brown (10 YR 3/2) clay; medium fine, subangular blocky structure; firm; neutral; abrupt, smooth boundary.

Blg-8 to 13 inches, dark-grey (10 YR 4/1) clay; common, medium, distinct, yellowish-brown (10 YR 5/8) mottles; medium, fine, angular blocky structure; firm; neutral; clear, smooth boundary.

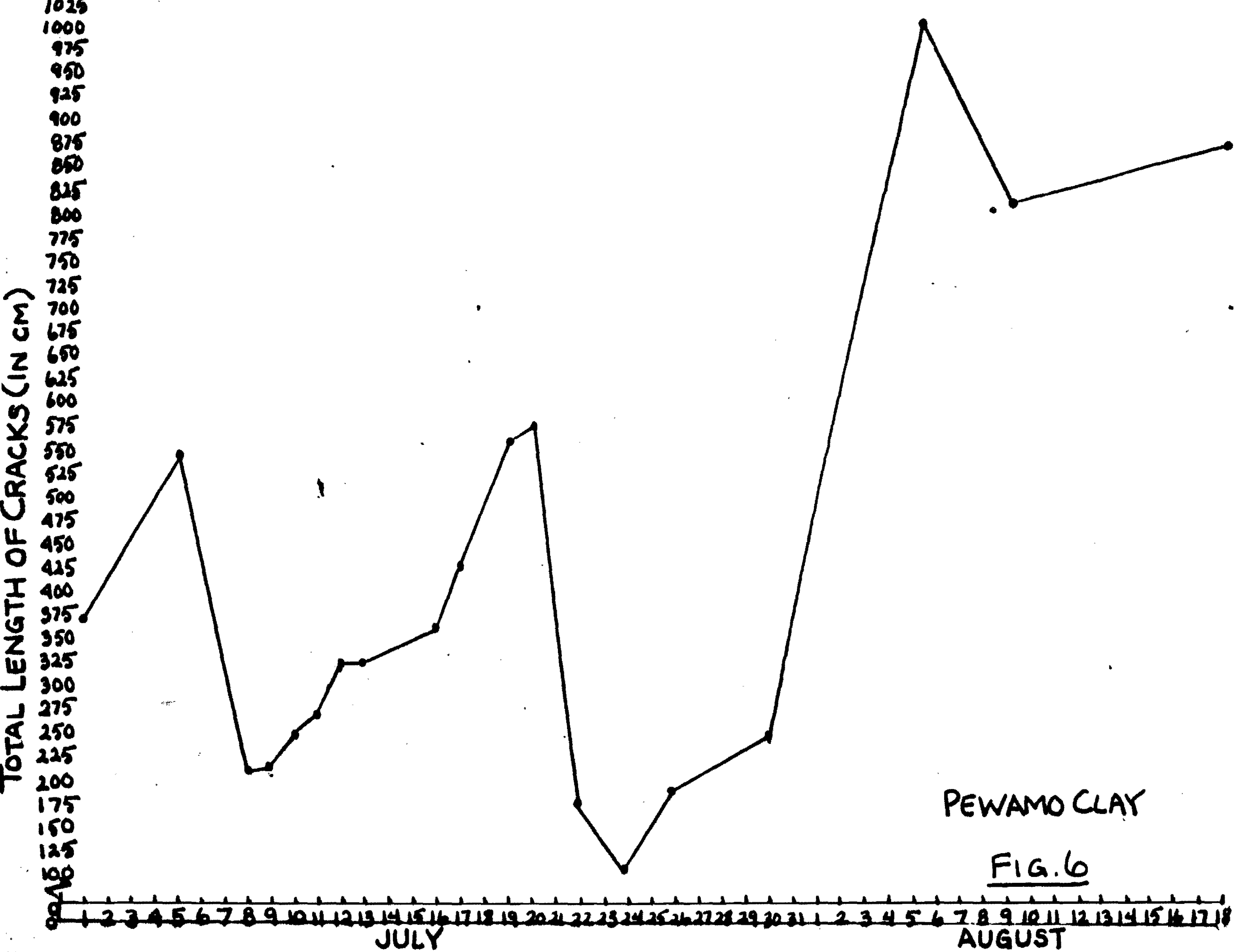


FIG. 6

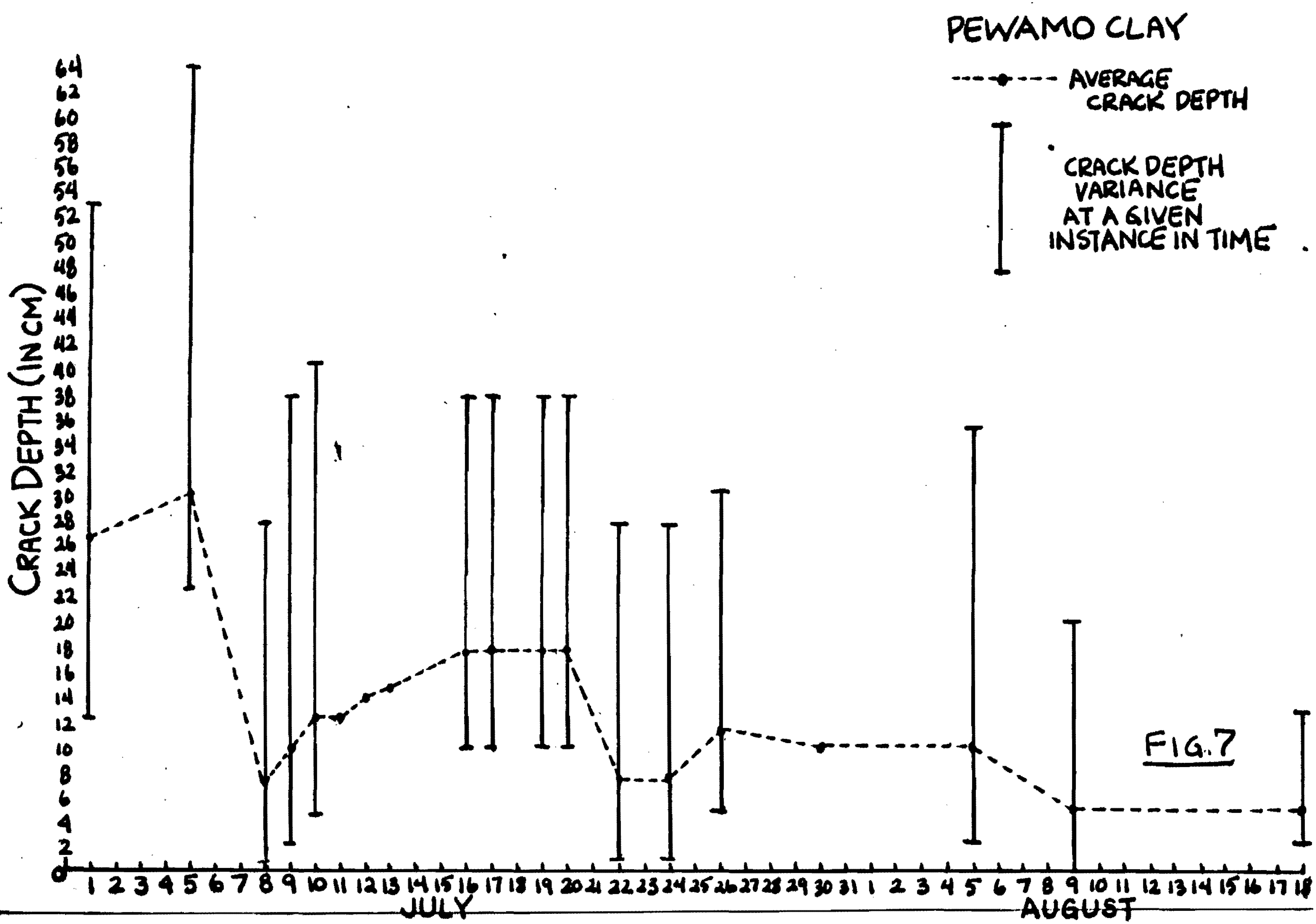

PEWAMO CLAY
AVERAGE CRACK DEPTH
CRACK DEPTH VARIANCE AT A GIVEN INSTANCE IN TIME
CRACK DEPTH (IN CM)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JULY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
AUGUST

FIG. 7

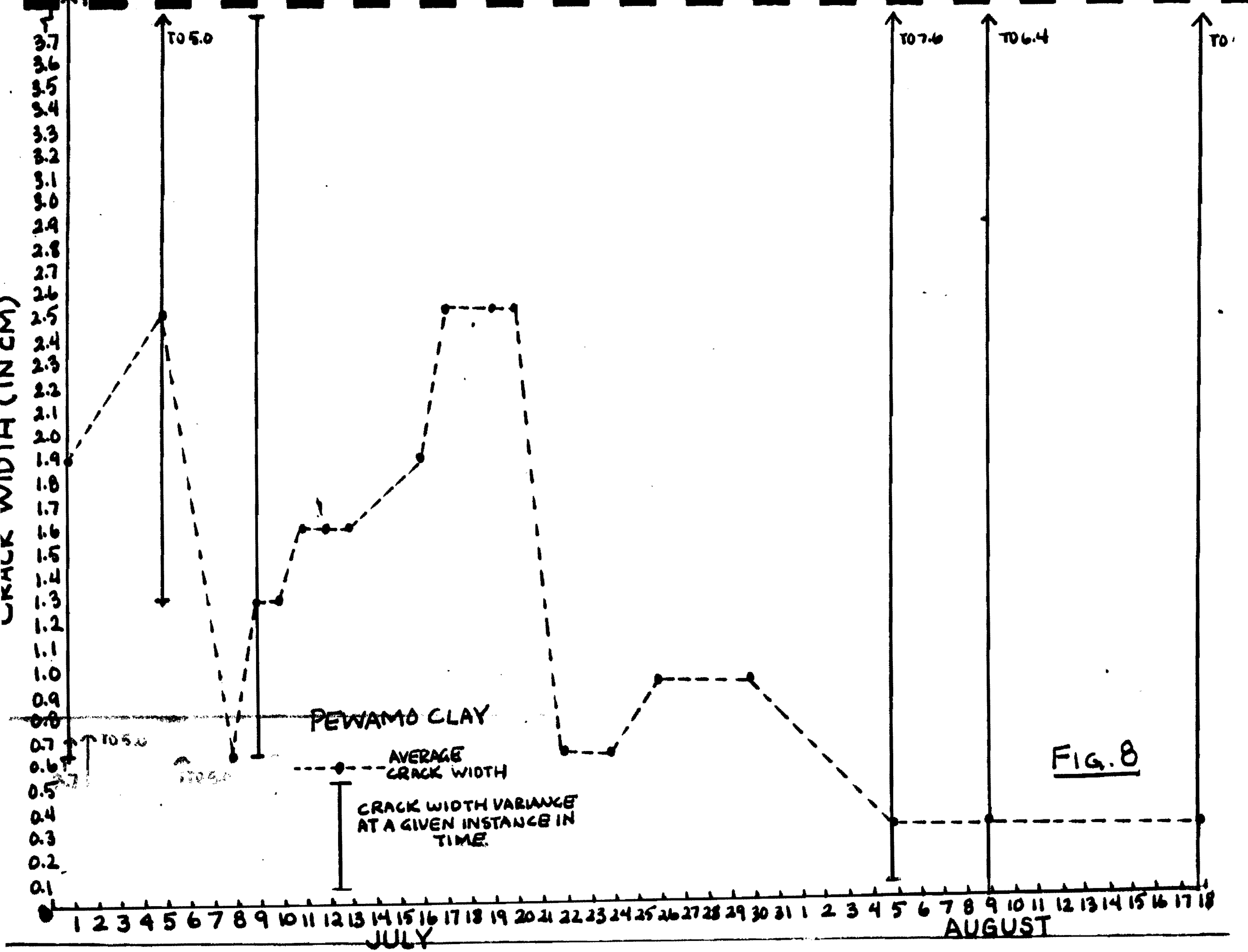

CRACK WIDTH (IN CM)
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
TO 5.0
TO 7.6
TO 6.4
PEWAMO CLAY
AVERAGE CRACK WIDTH
CRACK WIDTH VARIANCE AT A GIVEN INSTANCE IN TIME.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JULY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
AUGUST

FIG. 8

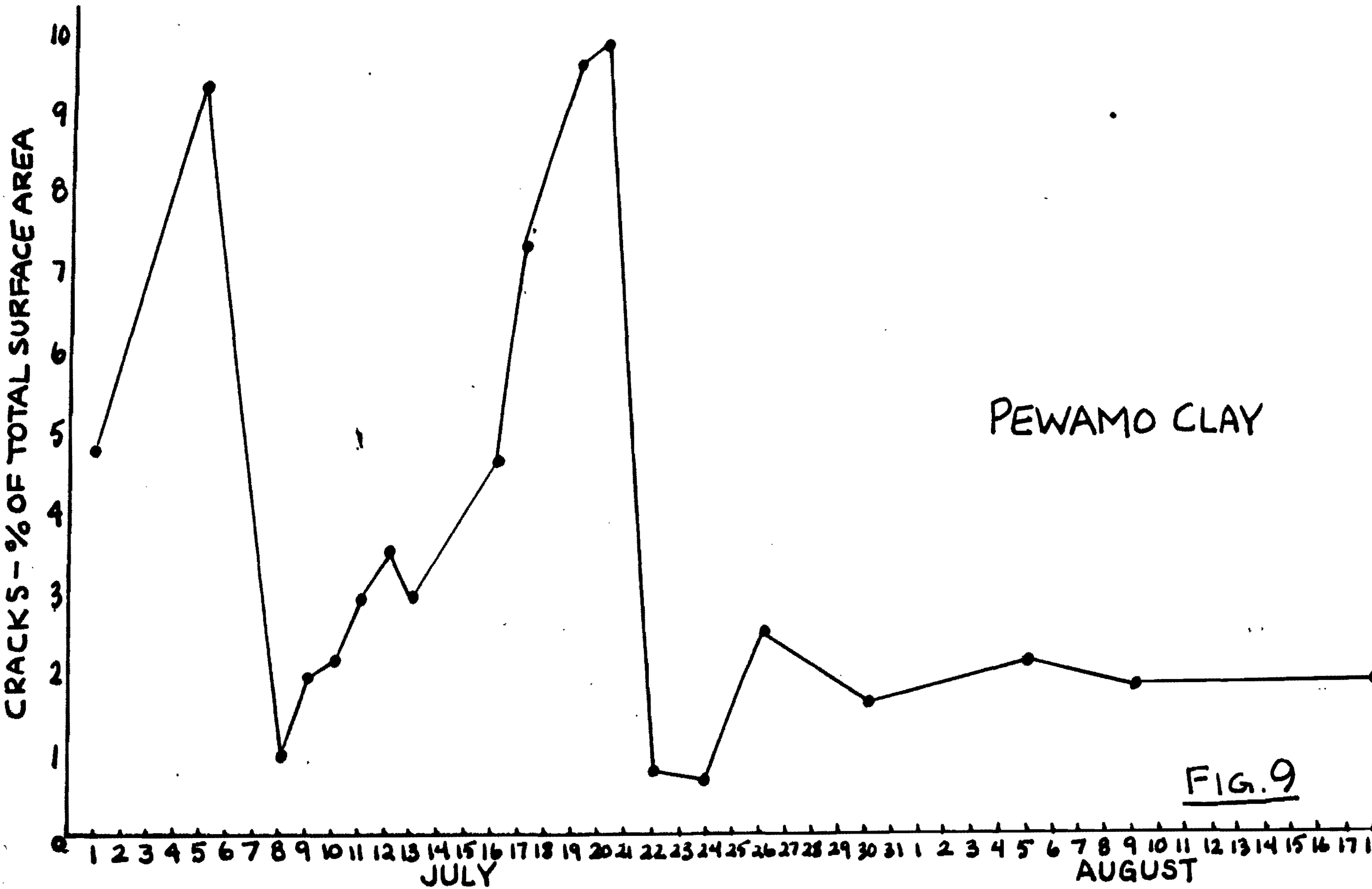
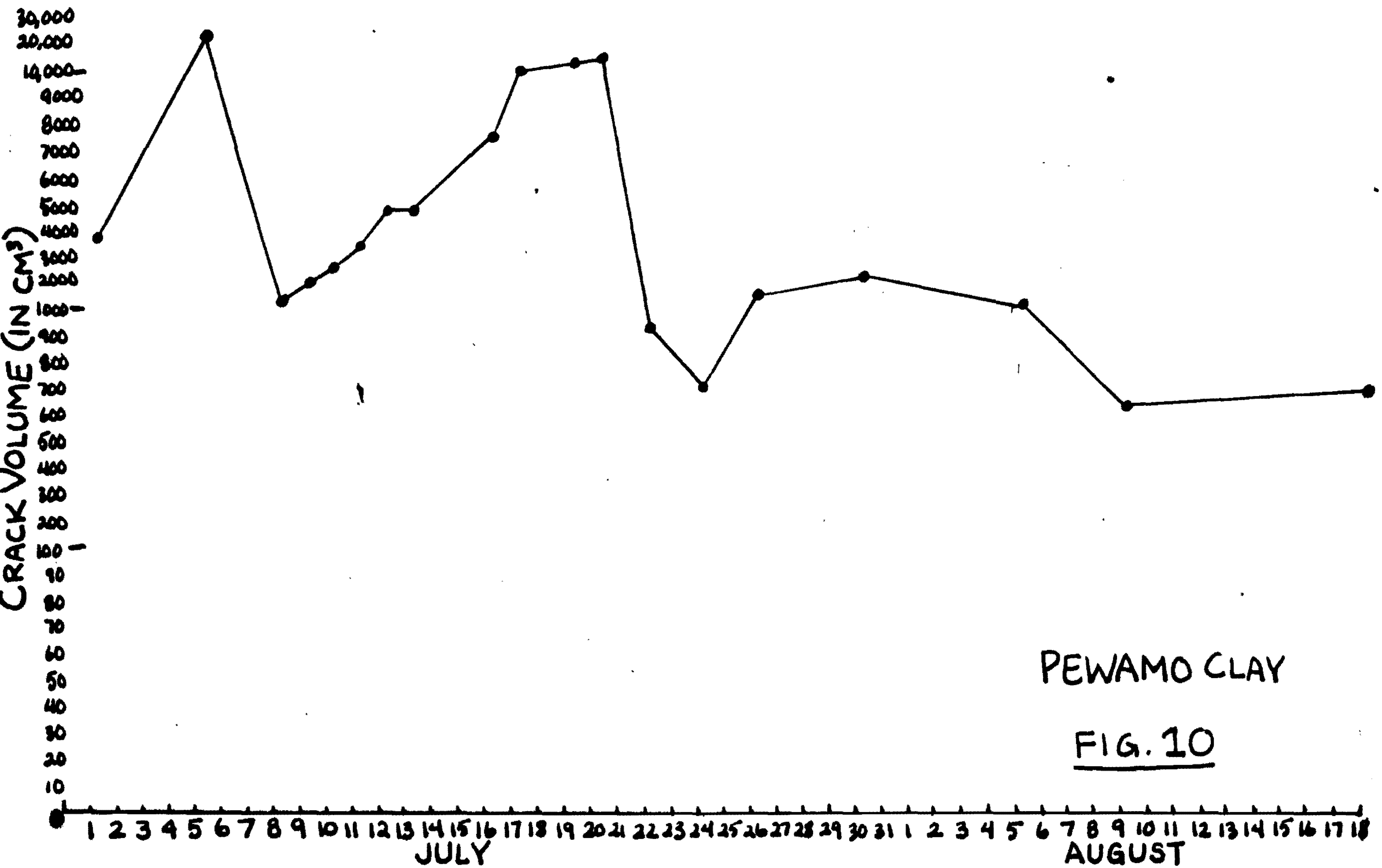

PEWAMO CLAY
CRACKS – % OF TOTAL SURFACE AREA
0
1
2
3
4
5
6
7
8
9
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JULY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
AUGUST

FIG. 9



PEWAMO CLAY

FIG. 10

B21tg-17 to 22 inches, grey (10 YR 5/1) clay; common, medium, distinct, yellowish-brown (10 YR 5/8) mottles; moderate, medium, subangular blocky structure; firm; thin continuous, grey (10 YR 5/1) clay films; neutral; gradual, wavy boundary.

B23tg-22 to 34 inches, grey (10 YR 5/1) clay; common, medium, distinct, yellowish-brown (10 YR 5/4) mottles; moderate, medium, subangular blocky structure; firm, thin continuous, grey (10 YR 5/1) clay films on vertical faces; thin pitchy clay films on horizontal faces; few pebbles; neutral; gradual, wavy boundary.

B3-34 to 40 inches, greyish brown (10 YR 5/2) clay; common medium, distinct, dark yellowish-brown (10 YR 4/4) mottles; weak, medium, subangular blocky structure; firm; thin, patchy, grey (10 YR 5/1) clay films on vertical faces; mildly alkaline; diffuse, smooth boundary.

C1-40 to 44 inches, dark greyish-brown (10 YR 4/2) and grey (10 YR 5/1) heavy clay loam; common, medium, distinct, yellowish-brown (10 YR 5/8) mottles; massive; firm; moderately alkaline; calcareous; diffuse, wavy boundary.

C2-44+ inches, dark greyish-brown (10 YR 4/2) heavy clay loam; common, medium, distinct, yellowish-brown (10 YR 5/4) mottles; massive; firm; moderately alkaline; calcareous glacial till.

Rainfall

Rainfall at the Hoytville site was grouped closely together in the middle of the data sampling period. The same hot, dry weather was experienced on July 11th, 17th as at the Pewano plot and was very humid on the 20th. 0.5 inches, 1.6 inches, 0.3 inches and 0.3 inches fell on July 21st-24th. 0.3 inches fell on both July 26th and 27th. 0.1 inch fell on July 29th. No additional fell during the data sampling period. (See Figure 11.)

Soil Moisture in Percent

Soil moisture fluctuated greater in the 0-6" increment than the 6-12" increment. Again, for the most part, the 6-12" increment was slightly higher except on a few occasions. (See Figure 12)

Total Crack Length

Total crack length fluctuated from a low of 56 cm on July 24th to a high of 947 cm on August 9th. (See Figure 13).

Crack Depth

Average crack depth fluctuated from a high of 25 cm on July 5th to a low of 5 cm on August 5th-18th. Variance of crack depth at a given time was usually about 18 cm. (See Figure 14)

Crack Width

Average crack width fluctuated from a high of 2.5 cm on July 19th and 20th to a low of 0.3 cm on August 5th. Variance at any given time was usually 2.5 cm. (See Figure 15)

Crack - Percent of Total Surface Area

The percent of the total surface area which was occupied by the cracks varied from a high of 5.6% on July 20th to a low of 0.2% on July 24th. (See Figure 16).

Volume of Cracks

The volume of the cracks within the soil varied from a low of 186 cm on July 8th to a high of 7,260 on July 20th. (See Figure 17)

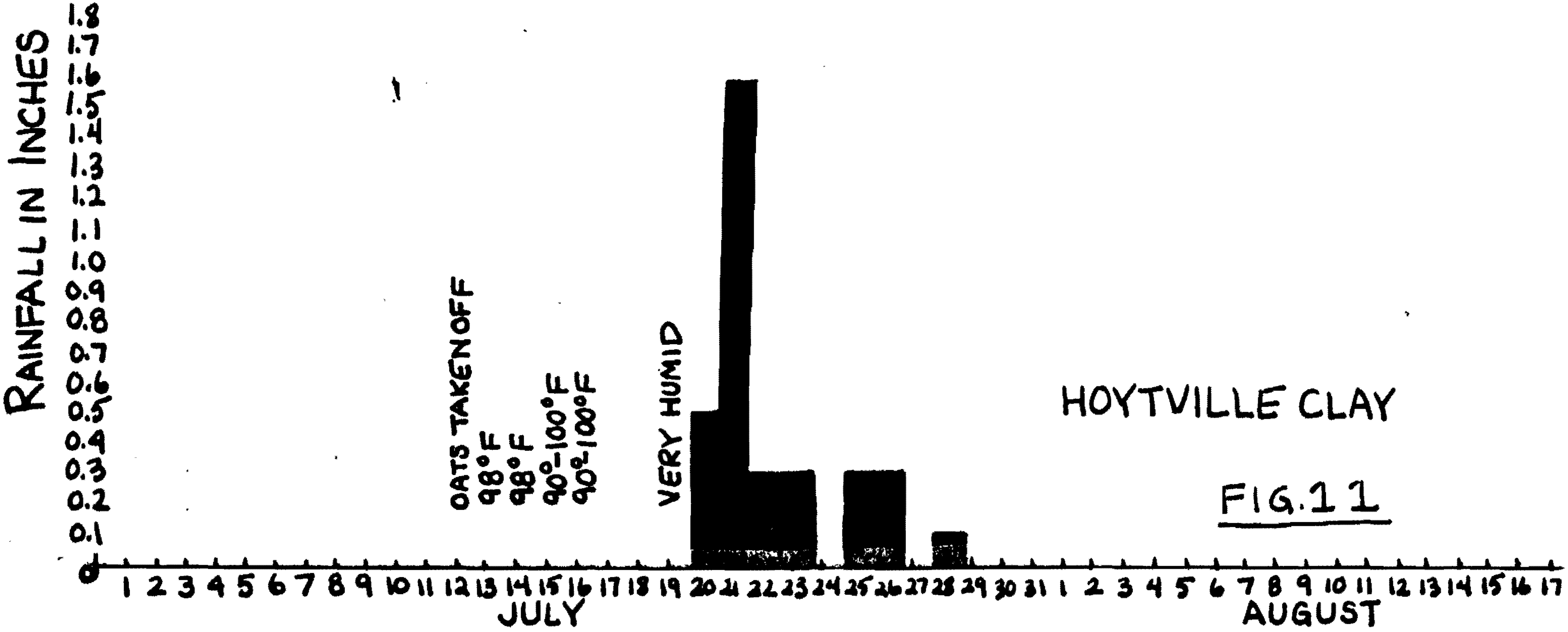
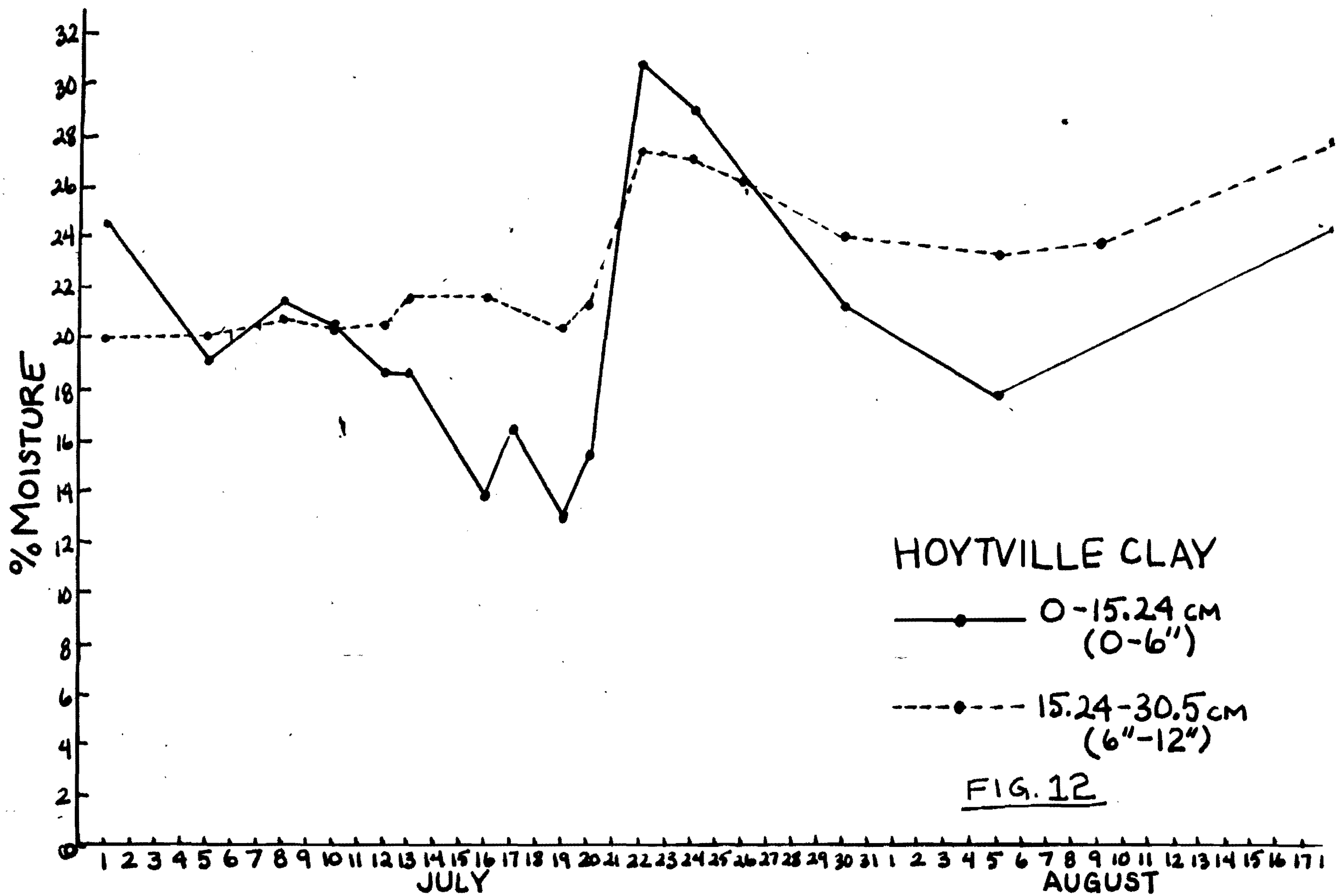
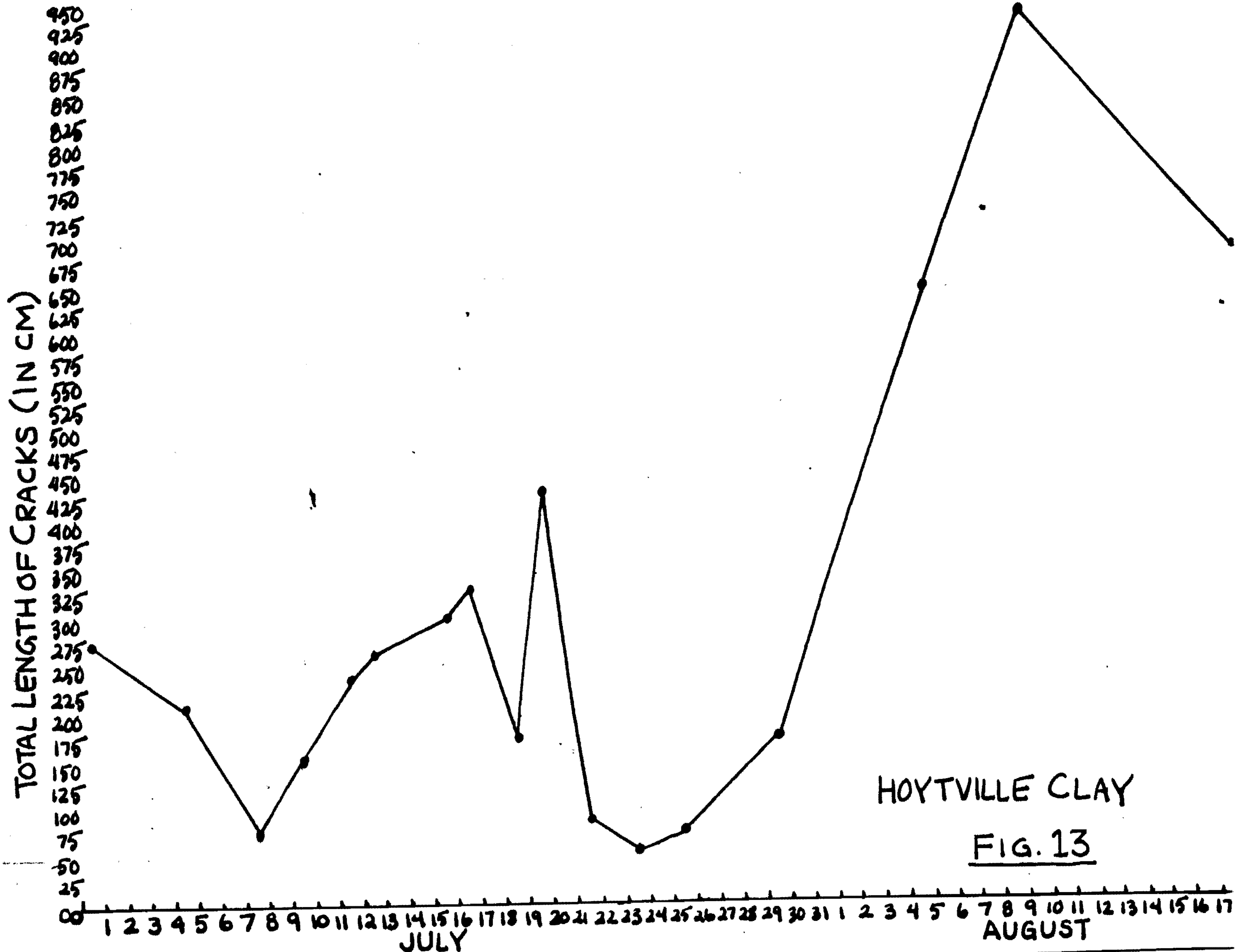

RAINFALL IN INCHES
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
OATS TAKEN OFF
98°F
98°F
90°-100°F
90°-100°F
VERY HUMID
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JULY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
AUGUST
HOYTVILLE CLAY

FIG. 11



% MOISTURE
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JULY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 1
AUGUST
HOYTVILLE CLAY
0-15.24 CM (0-6")
15.24-30.5 CM (6"-12")

FIG. 12



HOYTVILLE CLAY

FIG. 13

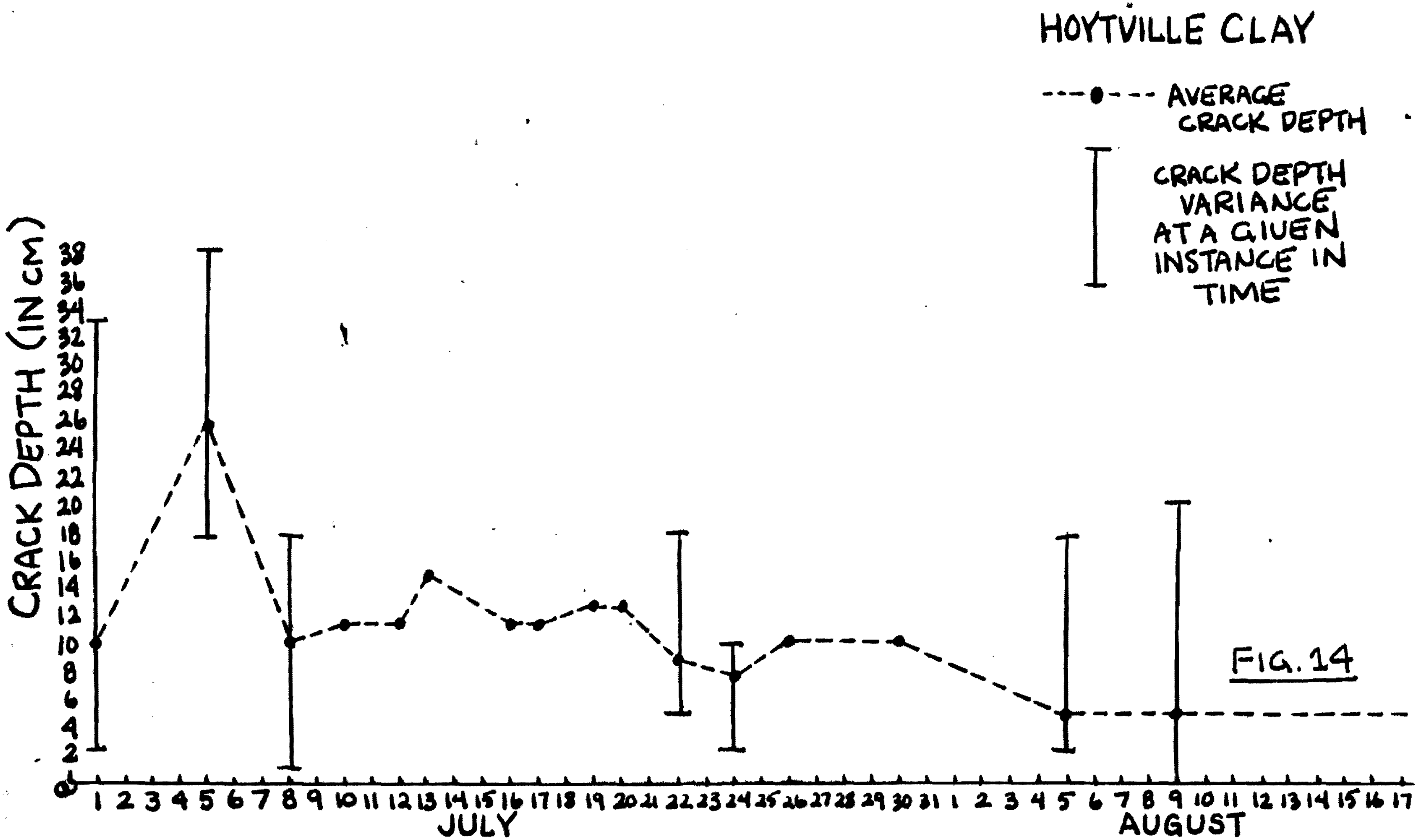

HOYTVILLE CLAY
AVERAGE CRACK DEPTH
CRACK DEPTH VARIANCE AT A GIVEN INSTANCE IN TIME
CRACK DEPTH (IN CM)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
JULY
AUGUST

FIG. 14

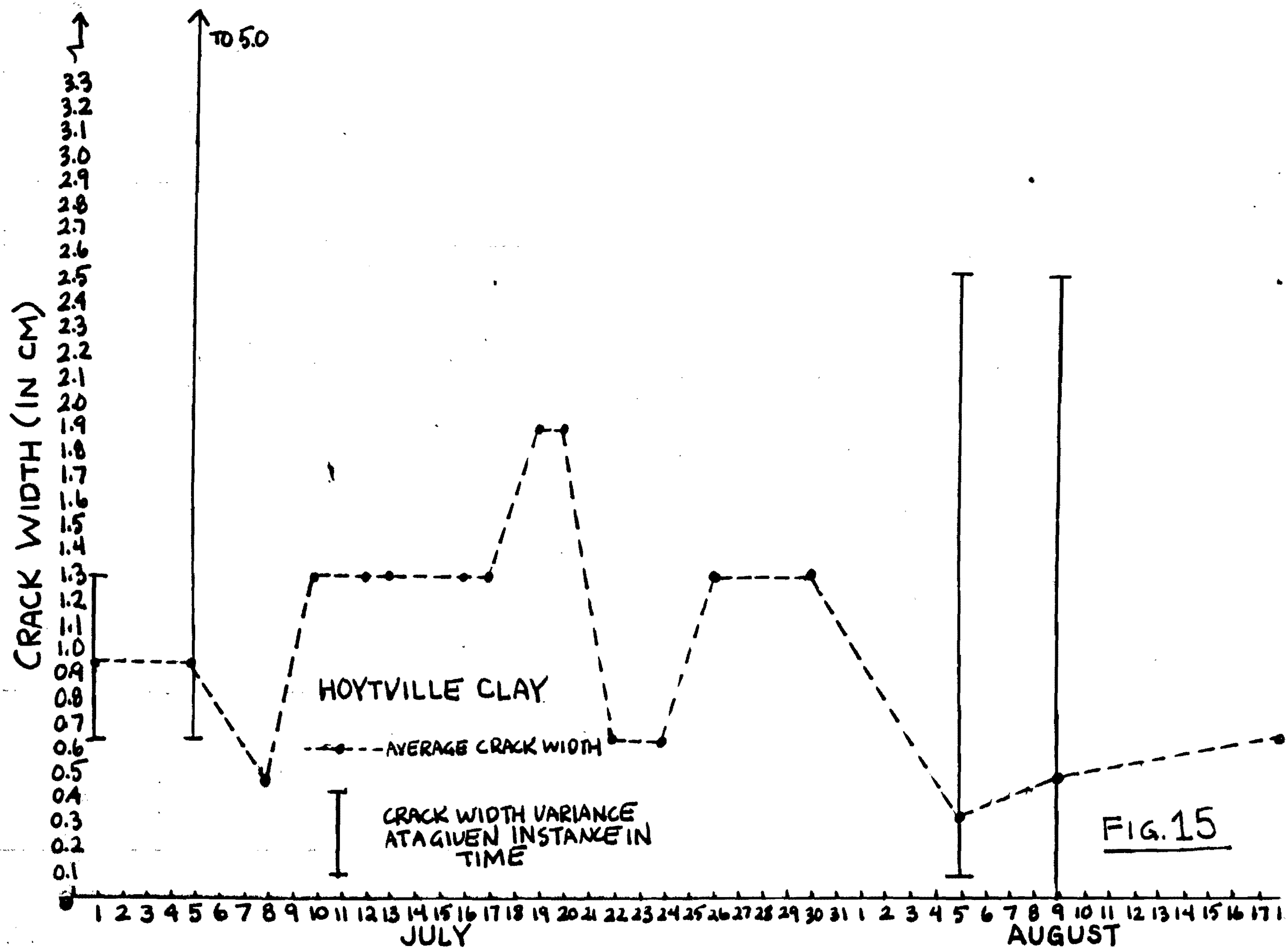

TO 5.0
CRACK WIDTH (IN CM)
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
HOYTVILLE CLAY
AVERAGE CRACK WIDTH
CRACK WIDTH VARIANCE AT A GIVEN INSTANCE IN TIME
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 1
JULY
AUGUST

FIG. 15

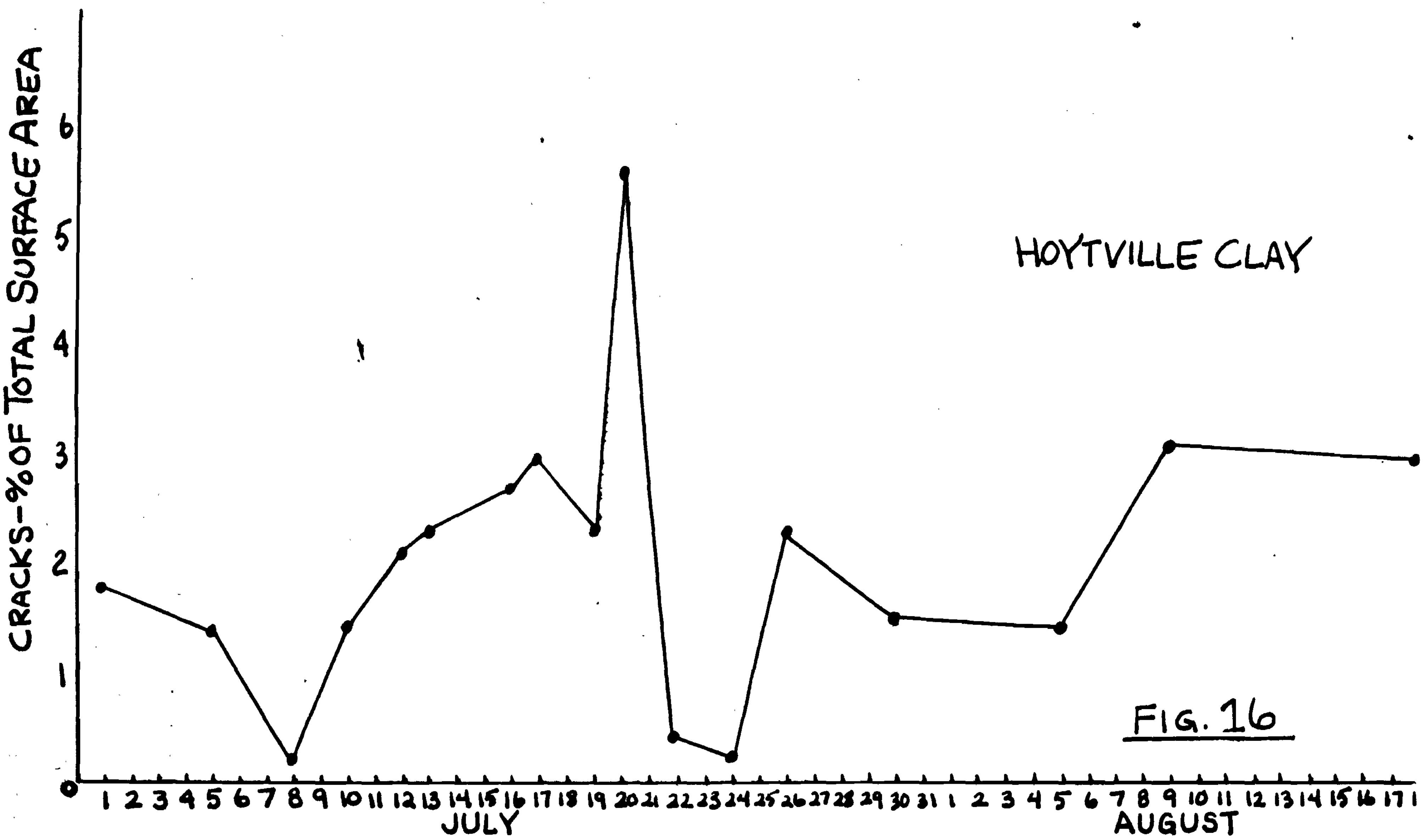
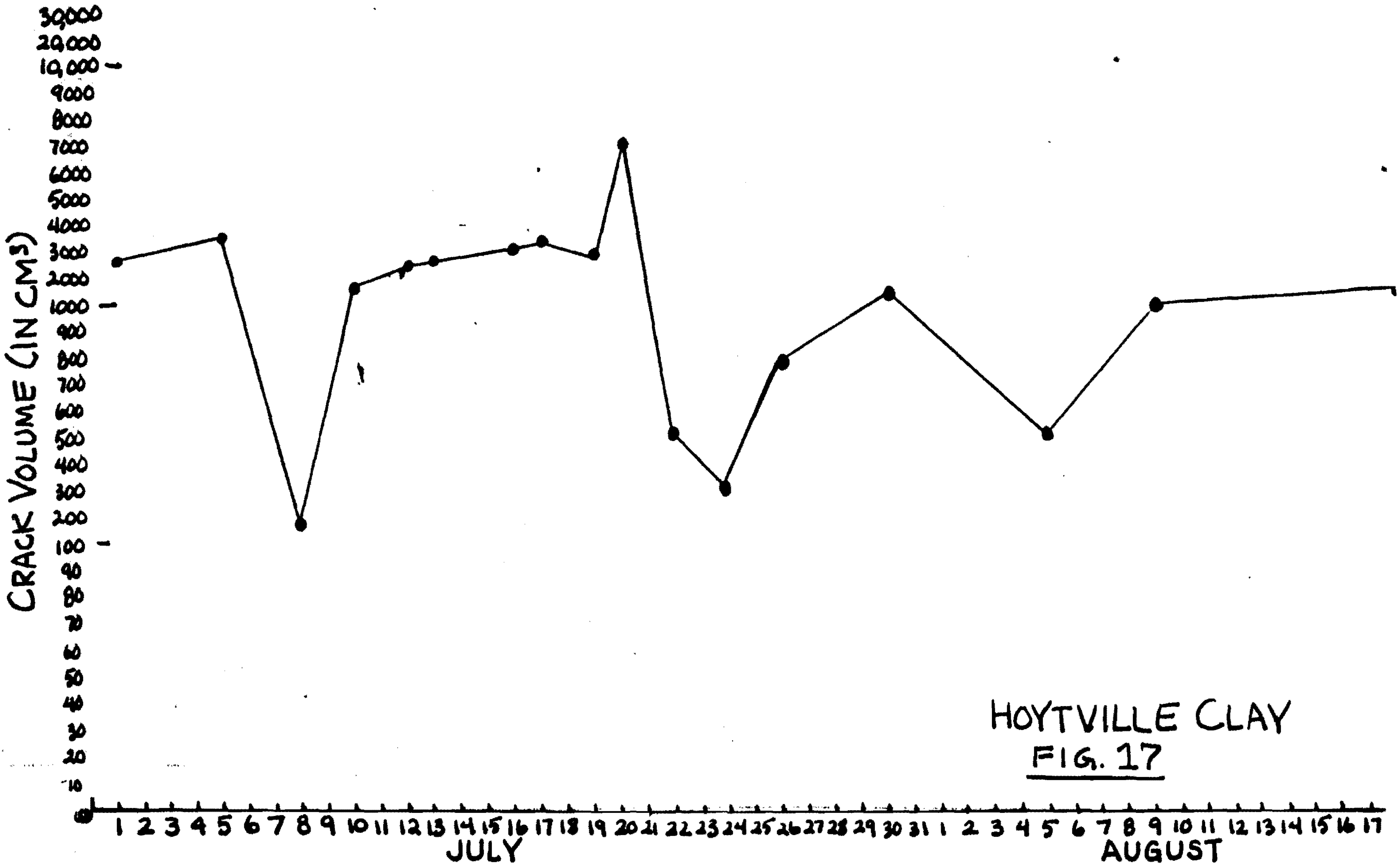

HOYTVILLE CLAY
CRACKS-% OF TOTAL SURFACE AREA
0
1
2
3
4
5
6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 1
JULY
AUGUST

FIG. 16



HOYTVILLE CLAY

FIG. 17

Pewamo and Hoytville Sites Compared

In all parameters of crack magniture the Pewamo Clay exceeded the Hoytville clay.

Cecil Flesher the S.C.S. Defiance Area Soil Scientist thought the Pewamo had a high percent of clay in the B21tg horizon. *8*

COLE (coefficient of Linear Extensibility) was calculated in the soil physics lab using the Saran coated-clod method to give bulk densities at oven dry and 1/3 atmosphere.

Three samples were run at each site to ensure accuracy.

$$COLE = {\frac{Dbd}{Dbm}}^{1/3} - 1 \quad *9*$$

Where: Dbd = Bulk Density Dry (oven)

Dbm = Bulk Density Moist (1/3 atmosphere)

Paulding?

Questionable Site (Representative)

Representive Sites

Sample	HOYTVILLE CLAY COLE	PEWAMO CLAY COLE
1	0.0473	0.1066
2	0.0413	0.1051
3	0.0550	0.1008
Average	0.0478	0.1042

Since the Pewamo clay had a much greater COLE value and received a greater fluctuation of Rainfall (moisture) this would account for the difference in crack magnitudes.

DISCUSSION

Soil Moisture

Soil moisture fluctuated directly for the most part with rainfall at both sites. However, other factors also seemed to affect soil moisture. When the wheat was harvested soil moisture jumped dramatically July 12th on the Pewamo site, probably reflecting reduced evapo-transpiration which removed moisture from the soil. (See Figure 4&5)

A similar jump did not occur at the Hoytville site when the oats were taken off, probably because alfalfa was underseeded as a companion crop. When the canopy which the oats created was removed, the alfalfa began growing more vigorously and removed more moisture from the soil. (See Figure 11 and 12.)

Hot, dry, windy weather also increased evapo-transpiration from the soil, expecially the 0-6" depth near the surface. This is reflected at the Hoytville site July 12th-16th. (See Figure 11 and 12)

Humidity in the atmosphere also seemed to affect soil moisture. Increased humidity reduced evapo-transpiration from the soil. This could be the case on July 20th at the Pewamo site. (See Figure 4 and 5).

Soil Moisture Relationship to: Length of Cracks

Graph

In general, length of cracks varied inversly with soil moisture. However, following the rains of the week of July 21st, crack length increased greatest at both sites. This seemed to result from the intense rains breaking up the soil aggregates and compacting the soil, thus causing crusting to occur. As the crust dryed many new smaller and more shallow cracks appeared. (See Figure 5 and 6; 12 and 13)

Width of Cracks

Crack width also varied inversly with soil moisture. However, following the intense rains of the week of July 21st, crack widths became smaller because of crusting.

Variance of crack width was large at any given time, especially during dry and crusting periods. When soil moisture was high (after rainfall) only the largest cracks remained. As the soil dryed, these cracks became wider and many new thinner cracks developed off of the larger cracks. (See Figure 5 and 8; 12 and 15)

Crack Depth

Average crack depth did not fluctuate as great as the parameters of crack length and width. It also varied essentially inverse of soil moisture. However, following the rains the week of July 21st, the average depth became smaller because of the preponderance of shallow cracks due to crusting. (See Figure 5 and 7; 12 and 14)

Percent of Total Surface Area of Cracks

Surface area of the cracks varied inversly to soil moisture except during the crusting period. This could be due to reduced width of the cracks during this time.

Volume of Cracks

Graph?

Volume also varied inversly to soil moisture. Again, however, the crusting period did not reflect such a clear relationship.

Crack Effect Upon Infiltration

Infiltration through cracks in the soil could proce~~de~~ed much more rapidly than percolation through the inter-aggregate media of the soil. On Pewamo clay up to 10% and on Hoytville clay up to 6% of the rainfall could fall immediately into a crack. The remaining

How Do You Know?

raindrops that did not strike a crack could flow only a few centimeters to an open crack to infiltrate rapidly also.

On July 5th at the Pewamo site the total volume of the cracks was great enough to have held 0.41 gallons of water per square foot. This means that a rainfall of .66 (2/3rds) inch could have infiltrated immediately or 17,860 gallons/acre.

The average volume of cracks, however, for the two sites during the data gathering period was 0.04 gallons/square foot for Hoytville clay and 0.1 gallons/square foot for Pewamo clay. These values equal approximately 0.1 inch (1,742 gallons/acre) rainfall immediate infiltration capacity for Hoytville clay and 0.2 inch (4,356 gallons/acre) for Pewamo.

As the cracks were for the most part all inter-connected to large, deep cracks this huge, quick, influx of water could place large internal pressures upon the subsurface tile that the cracks happen to reach. These pressures could cause "blowouts" in the tile. Mr. Cusac, the landowner at the Hoytville site, stated that he had observed times when water had gushed several feet out of the tile outlets immediately after a summer convective rainstorm. *10*

Crusting could reduce infiltration.

Crack Effect Upon Sediment Loss

By observing the large amounts of water which the two soils could receive and conduct to a tile line during a dry period with a high degree of cracking magnitude, one might be led to the conclusion that highest sediment losses through tile would be during such a period.

Research by Schwab, however, has shown that sediment losses through tile were highest when soil moisture content was high. *11*

Recent research by M. L. Thompson, et. al. 1976 may provide an answer. Thompson stated the following: *12*

1. Northwest Ohio is composed of Calcareous soils (high lime sediments).
2. $CaCO_3$ and $H_2CO_3 \longrightarrow Ca^{++} + 2HCO_3^-$
3. Ca^{++} is the most important coagulation agent in this area, because it is the most predominante polyvalent cation.
4. Clay colloidal particles are negatively charged due to lattice substitution.
5. Like charges repel each other, therefore, the clay colloidal particles will repel each other and not coagulate.
6. Ca^{++} (polyvalent cations) however, attach themselves to the clay colloid and neutralize the negative charges on the clay colloids.
7. Therefore, the clay colloids do not repel each other and Van Der Waals Forces bring the colloidal particles together to form an aggregate. (Floccuation)

During dry periods Ca^{++} cation concentration in the soil solution is highest, therefore coagulation is highest and the clay particles are held together and would resist being moved (washed into a crack.)

At high soil moisture levels, however, Ca^{++} cation concentration is diluted, therefore, clay collodial particles repel each other due to a lack of Ca^{++} and disperse to fine individual colloidal particles which could be easily moved (washed into a tile line and remain in suspension to flow out the outlet and into a water body (which eventually drains into the Maumee.) More Research Needed? Measurements?

Possible Effects Upon Nutrient-Pesticide Losses

Some nutrients and pesticides have a high affinity for clay colloid particles and will attach themselves.

Some of these nutrients and pesticides could then travel with the clay colloid to the Maumee River or Lake Erie, However, in most cases the high affinity may be due to polyvalent charges, and might instead help coagulation of clay colloids. More Research Needed? Measurements?

SUMMARY

1. Soil cracking parameters of length, depth, width, percent of total surface area, and volume were found to var~~r~~y inversely with percent of soil moisture (except during crusting periods). Graph?
2. Crack magnitude in all cases was greatest for the Pewamo site over the Hoytville, due to it's high COLE value.
3. Infiltration was affected by cracks. Huge quantities of rainfall could infiltrate immediately and cause pressure on tile drainage. How Bad Is Problem?
4. Cracks could provide a route for sediment to pass through tile lines and into water bodies which empty into the Maumee River Basin. However, greatest sedimentation occurs at higher levels of soil moisture PERHAPS due to the ability of Ca^{++} to coagulate clay colloids at lower soil moisture levels. What Should Be Done?
5. Nutrients and pesticides may attach themselves to the clay colloid and be transported with it, but might also aid in coagulation in the case of polyvalent cations.

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